TECHNICAL UNIVERSITY OF MOMBASA

FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF BUILDING & CIVIL ENGINEERING

UNIVERSITY EXAMINATION FOR:

BACHELOR OF SCIENCE IN CIVIL ENGINEERING

ECE 2408: THEORY OF STRUCTURES V

SPECIAL/SUPPLEMENTARY EXAMINATION

SERIES: SEPTEMBER 2018

TIME: 2 HOURS

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, examination pass and student ID

-Drawing instruments.

This paper contains FOUR questions

Answer question ONE and any TWO questions.

Marks for each question are indicated in the parenthesis.

Do not write on the question paper.

QUESTION ONE (COMPULSORY) 30 marks

a) Define the following terms as used in FEM analysis

i) Nodal points

ii) Nodal planes

iii) Continuum

iv) Secondary unknowns

(2 marks)

b) Define the term discretization and using clear sketches, explain the guidelines of this process when analyzing using element FEM analysis

(6 marks)

c) From Hookean theorem and matrix method of analysis, show that the system stiffness matrix **[K]** obtained by superimposing the coefficients of stiffness of the elemental stiffness matrices is given by:

$$
[\mathbf{K}] = \begin{array}{c} \begin{array}{ccc} u_1 & u_2 & u_3 \end{array} \\ \begin{bmatrix} A_1E_1/l_1 & -A_1E_1/l_1 & 0 \\ -A_1E_1/l_1 & A_1E_1/l_1 + A_2E_2/l_2 & -A_2E_2/l_2 \\ 0 & -A_2E_2/l_2 & A_2E_2/l_2 \end{bmatrix} \end{array} \begin{array}{c} u_1 \\ u_2 \\ u_3 \end{array}
$$

(6 marks)

d) List **THREE** advantages and **THREE** Disadvantages of finite element method

(3 marks)

e) List FIVE areas where FEA can be applied? (2.5 marks)

f) What is the difference between truss (or rod or bar) elements and beam elements?

(1.5 marks)

g) Given the truss structure shown, calculate the stress and strain in truss element in figure Q1(g) if:

A1 = 0.0004 m2

E1 = 200x109 Pa

L1 = 2 m

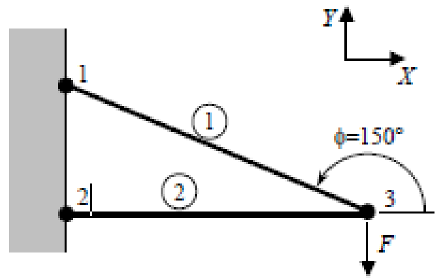

Figure Q 1(g)

$$D = \begin{Bmatrix} u1 \\ v1 \\ u2 \\ v2 \\ u3 \\ v3 \end{Bmatrix} = \begin{Bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ -1 \text{ x } 10-3 \\ -2 \text{ x } 10-3 \end{Bmatrix}$$

(14 marks)

ANSWER ANY TWO QUESTIONS FROM THIS SECTION

QUESTION TWO (20 marks)

Using the matrix displacement method, determine the forces in the members of the plane pin-jointed truss in figure Q3, which is free to move horizontally at node **3,** but not vertically. It may also be assumed that the truss is firmly pinned at node 1, and that the material and geometrical properties of its members are given in the Table Q2 below.

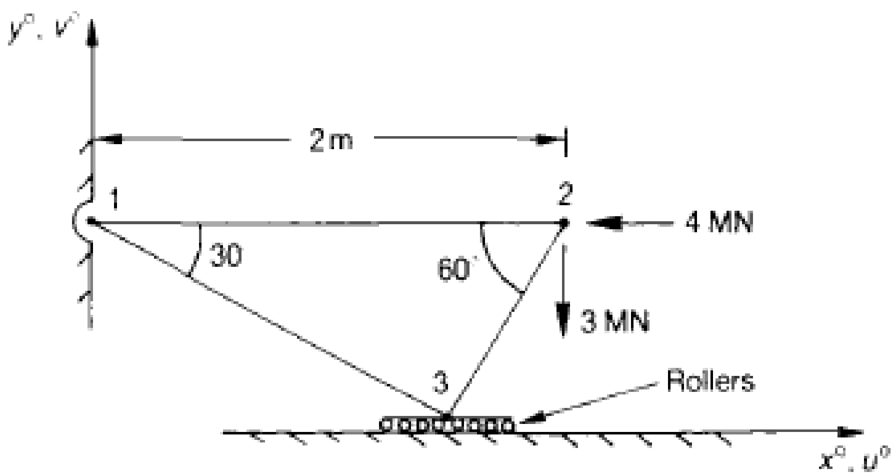

Figure Q2

Table Q1

Member	A	E
1–2	$2A$	E
1–3	A	$3E$
2–3	$3A$	$2E$

QUESTION THREE (20 marks)

Determine the nodal displacements and bending moments for the built-in beam shown in figure Q3

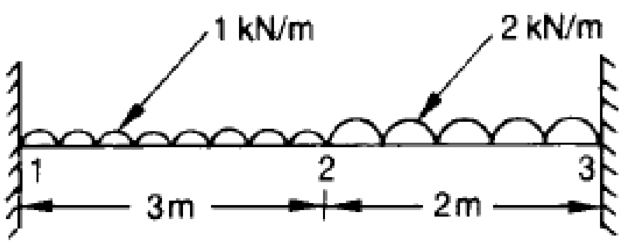

Figure Q3

QUESTION FOUR (20 marks)

Using the **matrix** displacement method, determine the nodal bending moments for the rigid-jointed plane frame shown in figure Q4 below.

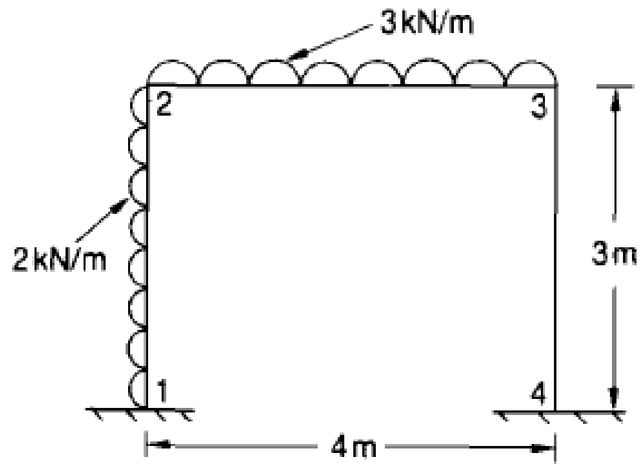

Figure Q4

NB. To determine {qF}, it will be necessary to fur the structure at its nodes and calculate the end fixing moments

HINTS:

i) For members generally subjected to axial, lateral and rotational forces:

Element stiffness matrix in local coordinates, $[k] = \begin{bmatrix} \frac{AE}{L} & 0 & 0 & \frac{-AE}{L} & 0 & 0 \\ 0 & \frac{12EI}{L^3} & \frac{6EI}{L^2} & 0 & \frac{-12EI}{L^3} & \frac{6EI}{L^2} \\ 0 & \frac{6EI}{L^2} & \frac{4EI}{L} & 0 & \frac{-6EI}{L^2} & \frac{2EI}{L} \\ \frac{-AE}{L} & 0 & 0 & \frac{AE}{L} & 0 & 0 \\ 0 & \frac{-12EI}{L^3} & \frac{-6EI}{L^2} & 0 & \frac{12EI}{L^3} & \frac{-6EI}{L^2} \\ 0 & \frac{6EI}{L^2} & \frac{2EI}{L} & 0 & \frac{-6EI}{L^2} & \frac{4EI}{L} \end{bmatrix}$

Element stiffness matrix in global coordinates, $[K] = [T]^T.[k].[T]$

$[k]$ = element stiffness matrix in local coordinates (all elements)

$[T]$ = coordinate transformation matrix

ii) The elemental stiffness matrix for Rigid-jointed plane frames in local co-ordinates [k] is given by:

$$
[\mathbf{k}_b^*] = EI \begin{array}{c}
\begin{array}{cccccc} \quad u_1^* \quad & \quad v_1^* \quad & \quad \theta_1 \quad & \quad u_2^* \quad & \quad v_2^* \quad & \quad \theta_2 \end{array} \\
\begin{bmatrix}
\frac{12}{l^3}s^2 & & & & & \\
\frac{12}{l^3}cs^2 & \frac{12}{l^3}c^2 & & & & \\
\frac{6}{l^2}s & -\frac{6}{l^2}c & \frac{4}{l} & & & \\
-\frac{12}{l^3}s^2 & \frac{12}{l^3}cs & -\frac{6}{l^2}s & \frac{12}{l^3}s^2 & & \\
\frac{12}{l^3}cs & -\frac{12}{l^3}c^2 & \frac{6}{l^2}c & -\frac{12}{l^3}cs & \frac{12}{l^3}c^2 & \\
\frac{6}{l^2}s & -\frac{6}{l^2}c & \frac{2}{l} & -\frac{6}{l^2}s & \frac{6}{l^2}c & \frac{4}{l}
\end{bmatrix}
\end{array}
\begin{array}{c} \\ u_1^* \\ v_1^* \\ \theta_1^* \\ u_2^* \\ v_2^* \\ \theta_2 \end{array}
$$